to publish a text-book in accordance with the plan adopted in this pamphlet. The objects are, "first to present a new method of deriving the differentials of functions by means of their algebraic characteristics with the aid of a few elementary properties easily established, and secondly to show that the method of rates or fluxions may be advantageously used for the purposes of instruction, and the use of infinitesimals, limits, and series entirely avoided until the student is well grounded in the elements of the calculus."

The first seven articles under the head "the Newtonian Method of Fluxions," treat of the methods in general use at the present time, and contain extracts from Todhunter, Lacroix, Carnot, and Cournot, especially directing attention to the positive advantages of the Newtonian method, as set forth by the last-named writer. The next six articles are occupied with the "Proposed Method of treating the Differential Calculus."

The remaining half of the pamphlet is given to algebraic and transcendental functions. It would be very interesting to lay before our readers an account of the ingenious methods adopted by our authors, but it would take up too much space. Some idea of the original paper (and there are no great differences, we fancy, between the two publications) can be got from an account of it furnished by Mr. J. W. L. Glaisher, F.R.S., in vol. iv. (pp. 58-64) of the *Messenger of Mathematics* (1875).

Altogether, on a review of the three books before us, we anticipate that mathematical studies are destined to occupy a more prominent position in the American colleges and schools than they have in the past.[1]

R. TUCKER

1 We are confirmed in our views on this subject by a perusal of Dr. Sylvester's characteristic address at the Johns Hopkins University on Commemoration Day, February 22, 1877.

## LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

### Visibility of the Ultra-Violet Rays of the Spectrum

It is well known how surprisingly rich in rays of high refrangibility the spectrum of the electric arc formed between carbon points is, above that of all other artificial flames; and also how far beyond the ordinarily discernible rays of the solar spectrum, formed by a glass prism, light may be traced by eyes carefully shielded, and raised to the highest susceptibility to perceive it. The name of "lavender-grey" rays has been given to them from a colour of that tint which they are considered to possess, but the term "ultra-violet," which is more commonly used, betrays perhaps a lingering doubt as to the sensible existence of another order of coloured rays in the spectrum distinct from the violet and superior to it in refrangibility, which has yet been detected by very close and careful observation. All doubts of this kind, which from want of sufficient acquaintance with that part of the spectrum I have myself been hitherto rather too prone to entertain, have lately been quite dispelled by frequent observations of the spectrum of the electric arc between carbon points thrown by a quartz prism on a white paper screen. The violet end of the spectrum terminates rather abruptly, or at least beams with bright colour that fades off very quickly; and in the dark space beyond it three more refrangible bright bands are visible with more or less distinctness. The middle one of the three is the brightest, and from its perfect freedom from colour, in which it contrasts most remarkably with the strongly-tinted light-belt near it, and its distant separation from the violet termination of the continuous spectrum, I at first hastily ascribed it to a "ghost," or faint image of the slit, indirectly refracted and reflected through the prism, and thrown with the spectrum on the screen. That it is not so, however, is shown by the action of these three lines on fluorescent substances, of all of which that I have tried they excite the fluorescence most strongly, especially that of fluorescin, eosin, rose of Magdala, and other solutions, all of which alike show these rays to be clearly defined and well-insulated spectral bands. In particular, the solutions of æsculin, paviin and amido-terephthalic acid are only excited by these "ultra-violet" lines, and not by any rays in the spectrum of lower refrangibilities, clearly showing that the vigorous fluorescence that they produce is not the effect of any ordinary light-beam of common refrangibility, irregularly transmitted by the prism, but that they are well-marked rays, probably of carbon, in the spectrum of the voltaic arc. The light of the middle band is bright enough to be easily reflected and examined separately from the rest of the spectrum on a white screen, where it is so nearly grey or colourless that it scarcely admits of being ranged in any colour scale, although the name "lavender-grey" perhaps expresses better than any other term the faintest possible tone of colour which, if it exhibits any at all, this almost purely neutral, or steel-grey band of rays may possibly be suspected to possess. It is a little more strongly absorbed by ordinary plate-glass than the neighbouring violet bands; but it remains visible in the spectrum of the arc formed by an ordinary flint glass prism, though much spread out and enfeebled by the dispersion, which greatly exceeds that of a quartz prism of the same refracting angle. It is perhaps for this reason that it is not perceptible in the spectrum of the arc as usually projected on a screen with a fluid-prism of bisulphide of carbon, but if the latter is replaced by benzine, which disperses the light less than flint glass, it forms a pretty conspicuous grey band in the spectrum. The other two lines or bands are so much fainter than the principal one, that in general they can only be found with the help of a fluorescent substance, and where so faintly visible it is not possible to speak positively as to their colour. The less refrangible is very near the violet termination of the spectrum, and when well seen it shares its violet tinge; the more refrangible one is nearly as far beyond the principal grey band as this band is beyond the margin of the violet, and as far as its weak light allows one to distinguish, it is of the same colour as the brightest band. In order to determine their positions, some measurements were made of metallic lines, and of the spectra of sodium, lithium, thallium, and strontium in the arc, with the result that the violet part of the continuous spectrum extends to the closely-neighbouring positions of the hydrogen line H$\delta$ ($h$), the potassium flame-spectrum line K$\beta$, and the last violet line in the arc spectrum of a salt of strontium. The first faint outlying ray occupies nearly the position of $H_1$ in the solar spectrum, and it is therefore in the true violet region of the spectrum, as its colour faintly indicates. The prominent grey line begins with its brightest edge about as much further beyond this, from the end of the violet field; and becoming weaker from there, it is about twice as broad as the distance between the two Fraunhofer lines H, its mean position in the spectrum being nearly as far from H as H is from $h$, reckoning the distances as they would be seen with the quartz prism and with solar light. The third faint line occurs about as far again from the violet as this band; and it lies at least as far beyond H as the distance between G and H in the solar spectrum. Yet it is visible there by glimpses, like the first faint member of the group, which it does not yet by any means surpass in the strength with which it produces fluorescence.

If any fresh proof was needed of the characteristic grey appearance of visible rays in this portion of the spectrum it was soon presented in one of the metallic spectra used to determine their positions. The spectrum of mercury exhibited a bright line (beautifully distinct when a fluid prism of benzine was used with a refracting angle of between 50° and 60°), much brighter than the principal grey carbon band, considerably more refrangible, and of the same tintless, and perfectly neutral grey appearance. Though not so distant from the violet as the most refrangible faint carbon line, it is yet according to the best measurements and identifications that were made, about as far beyond $H_1$ in a prismatic spectrum as $H_1$ is from G; and radiation of this high degree of refrangibility is evidently strongly luminous, when sufficiently intense, with homogeneous grey light characteristic of this region, and contrasting conspicuously in its appearance with the zone of violet colour, which often borders closely upon it in electric spectra.

The wave-lengths of the bands, and other positions in the spectrum, roughly obtained, by which it may be possible to identify some of them in photographic spectra, although open to some uncertainty from the inconstant length and strength of the arc of flame in the electric lamp, which confused and shifted some of the comparison lines, were as follows:—

| Electric Arc with Carbon Poles. | Wave-lengths. |
|---|---|
| End of the violet field ($h$, $K\beta$, and last violet line in arc-spectrum of strontium, 4,080–4,100) ... ... ... ... ... ... | About 4,100. |
| First light-band; faint violet-grey ($H_1$, 3,968; $H_2$, 3,933) ... ... ... ... ... | About 4,000–3,950. |
| Second do., strong grey band ... ... ... | About from 3,900 to 3,800. |
| (Strong grey line of mercury ... ... ... | About 3,700). |
| Third do., faint, grey ... .. ... ... ... | Between 3,600 and 3,500 (?). |

Other metallic arc-spectra probably present lines in this portion of the spectrum, of which it would be interesting to examine the apparent brightness and the colours. At present the most conspicuous that I have met with is the grey line of mercury, which is brighter and more refrangible than the grey band of the electric light between carbon points. Its very advanced position in the spectrum, and the absence, or negative appearance of colour in its pretty bright light, both taken together seem to indicate very clearly that the grey or "lavender-grey" division of the spectrum fully equals in extent, when seen prismatically, the violet, the indigo, the blue, or any of its other better known, and much more ordinarily visible companion regions, the seven Newtonian colour-spaces of the spectrum. A. S. HERSCHEL

College of Science, Newcastle-on-Tyne, April 26

## Pele's Hair

I HAVE read with great interest Mr. Moseley's description of Pele's Hair in NATURE (vol. xv., p. 547), since it furnishes information which I was most anxious to obtain. It seemed to me extremely probable that the analogy between Pele's Hair and the artificial furnace products would not be confined to the long fibres, and I did my best to ascertain whether irregular glassy spherules occurred along with the natural products. I was unable to obtain specimens for examination, but paid a visit to my friend Mr. J. G. Sawkins, F.G.S., who had explored the crater and collected the hair, in order to ask him whether he had ever noticed the pear-shaped spherules. He told me that he had never seen anything but the glassy fibres. I must say that I felt very much inclined to believe that the specimens usually collected are the material which has been blown some distance by the wind, consisting of the fibres from which most of the spherules have been broken. Mr. Moseley's letter in NATURE, and another which he has kindly addressed to me, make me believe that the analogy between the artificial and natural products is more complete than I was able to ascertain before Mr. Moseley's observations were published. In conclusion I would say that these facts in no way invalidate my arguments in respect to meteorites. They merely show that in certain cases the glassy volcanic spray, like melted furnace-slag, can to some extent collect into more or less imperfect spherules, so far analogous to those in meteorites as to indicate how those remarkable bodies were formed, but these spherules are accompanied by many fibres, which I have never yet seen in meteorites. This difference appears manifestly to depend on the difference in the temperature of the space into which the glassy spray was thrown. If the temperature of the air in the crater of Kilauea were equal to that of the melting point of the lava, we should almost certainly find, as in meteorites, many spherules and no hairs. H. C. SORBY

## The Critical Point of Carbonic Anhydride

As the writer is not aware that any attempts have hitherto been made by others to exhibit to a large class the phenomena attending the passage through the critical point of a liquid in the presence of its gas, he is of opinion that the following account of a method which he has found very successful may be of interest:—

Dr. Andrews's apparatus for the study of gases was employed in the experiments, and the image of the tube containing the carbonic anhydride was projected on a screen by means of the oxy-hydrogen lime-light and a solar microscope which magnified it about 120 diameters. Dr. Andrews's apparatus consists of a thermometer tube filled with carbonic anhydride and a second tube filled with dry air, which serves to measure the pressure applied. The lower ends of these tubes dip beneath the surfaces of mercury contained in test-tubes, which are suspended in strong copper cylinders communicating with each other, and filled with water, which presses on the mercury in the test-tubes. The pressure is applied by means of long steel screws which pass through the bottoms of the cylinders. For the filling and mounting of these tubes the University of Cambridge is indebted to the kindness of Dr. Andrews. The lantern was supported on three screws, which allowed it to be raised or lowered so as to bring any required portion of the thermometer tube into the field of view of the microscope. The best height for the lantern was found to be such that the top of the tube was rather less than half an inch above the axis of the microscope. When the oxygen was turned on, the radiation from the lime cylinder raised the temperature of the portion of the tube within the field of view above the critical point in little more than a minute, so that no other source of heat was required; but when the oxygen was turned off the tube cooled through several degrees.

The best method of performing the experiment is as follows:—The lantern having been properly adjusted, the gas should be lighted, the oxygen turned on, pressure applied until the surface of the mercury comes into the field of view and the microscope focussed so as to give a distinct image of this surface. The pressure should then be relieved and a blast of cold air from a bellows or gas bag directed against the tube. This will cool it considerably below the critical point. The pressure should then be increased, the cold blast being continued until the inverted image of the concave surface of the liquid reaches the middle of the field of view appearing as a broad dark line possessing considerable curvature, and, of course, concave downwards. The focussing screw should now be finally adjusted so as to give the best image of this surface, and the blast then stopped. Immediately after cutting off the blast the operator must obtain command over one of the screws and carefully increase the pressure as the temperature rises so as to keep the image of the liquid surface just above the centre of the picture on the screen. As the temperature and pressure increase the broad image of the surface becomes narrower and less concave until, as the temperature approaches the critical point, the line becomes very thin and faint and loses its curvature altogether; it then seems to explode into mist and vanish as the critical point is reached. Another half turn of the screw then produces the well-known clouds or flickerings, which are best seen on the screen somewhat below the middle of the field, and in a few more seconds all is steady. More pressure should then be applied until the mercury reaches the axis of the microscope, but no change of state will be manifested by the carbonic anhydride.

It is important that the image of the surface of the liquid should not be below the centre of the field of view on the screen, for if the liquid stand in the tube above the axis of the microscope, since the greatest heat is there concentrated, bubbles of gas are liable to be formed within the liquid and to damage the continuity of the surface. Perhaps the flickerings may be due to unequal temperatures at different parts of the tube, so that some are just above and others just below the critical point. The mode of propagation of a sound wave through a substance just at the critical point may be an interesting subject for inquiry.

After passing the critical point the blast of air should be directed against the tube for about a minute. This will, of course, cause the image of the mercury to descend upon the screen, but no change of state will appear to take place in the carbonic anhydride. The pressure should then be rapidly diminished by turning the screws, when a violent ebullition will be seen, showing that the whole of the contents of the tube had assumed the liquid state during the cooling, the gas having passed at the critical point into the liquid without breach of continuity, so that no indication of a change of state was apparent on the screen. On increasing the pressure and continuing the blast the liquid surface will again appear, and the experiment can be at once repeated. WM. GARNETT

Cavendish Laboratory, Cambridge

## Floating Cast Iron

HAVING read the interesting letter on this subject which appeared in NATURE (vol. xv., p. 529), I send the following copy of notes of experiments which I made about three years ago.